Transit Service Reliability

by

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Motivation

- Unreliability is seen as a widespread problem
  - Passenger impacts
    - Longer wait times
    - Need for trip time reliability buffer
    - More perceived crowding
  - Agency impacts:
    - Increased costs
    - Reduced ridership and revenue
    - Reduced operator morale
    - Public and political problem
    - Reduced effective capacity

Motivation

- **With Automated Data Collection Systems (AVL, AFC, APC) we can now measure reliability**
- **Automated scheduling systems make it easier to revise schedules**
- **Improved communications makes it easier to change service plan in real time**
- **Pressure is on for improvement …**

Problem Complexity

- **Reliability is not the only service dimension of value, also have:**
  - **Speed/trip time**
  - **Productivity**
- **Reliability means different things:**
  - **To different customers**
  - **On different services**
- **A single measure of effectiveness focused on reliability may lead to poor decisions**

BUT

- **We do need to measure performance *wrt* reliability**

Different Service Types

A. Low Frequency Service (typically defined as headways greater than 10-15 minutes)

- Most customers time their arrival at stops/stations based on expected service departure times (e.g. schedule)
- On-time performance is critical, for example:
  - 1 minute early to 5 minutes late
  - 0 minutes early to 3 minutes late
  - 0 minutes early to 1 minutes late
- Little interaction between successive vehicles

Different Service Types

B. High Frequency Service

- Most customers do not time their arrival at stops with service departures
- Expected wait time = F(mean and variance of headways)
- On-time performance not so critical
- Extensive interaction between successive vehicles:
  - Vehicle bunching
  - Long gaps

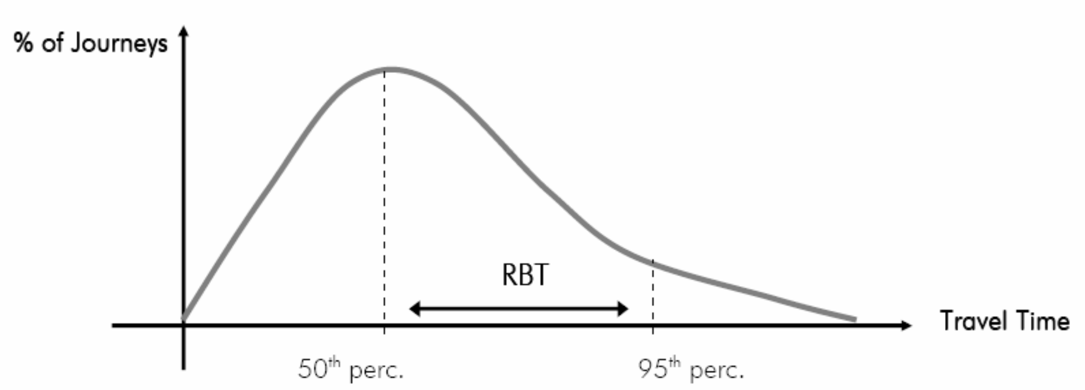
BUT

- Many high frequency routes have branches and short route variants
- So many customers may still behave like those on low frequency routes
- Schedule control is much easier than headway control…..

Reliability Metrics - Rail

A. High Frequency Service

- use tap-in and tap-out times to measure actual station-station journey times
- characterize journey time distributions measures such as Reliability Buffer Time (at O-D level):

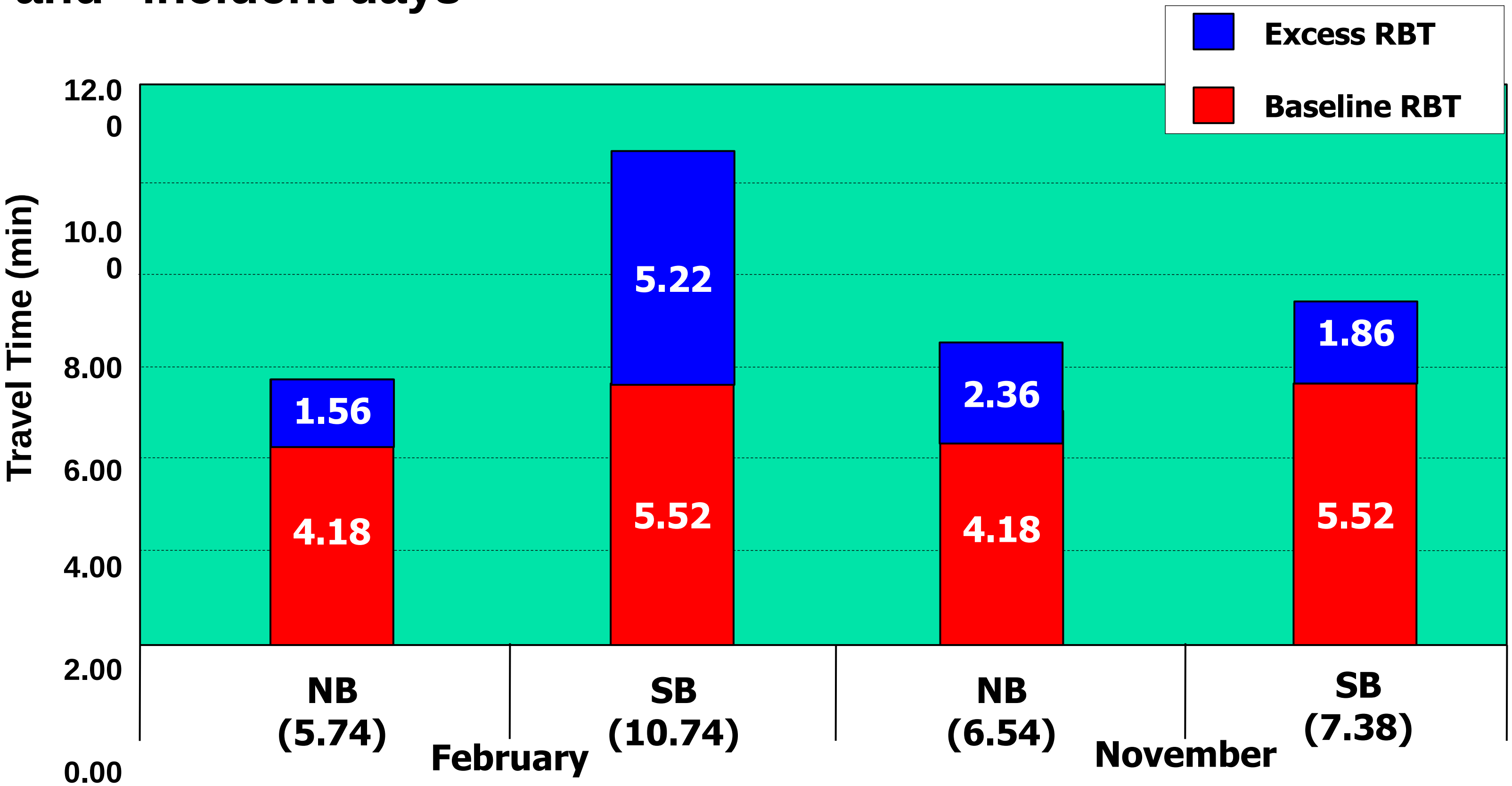


RBT = 95th percentile travel time – median travel time

Additional time a passenger must budget to arrive late no more than 5% of the time

Reliability Metrics - Rail

- Aggregate to line level by distinguishing between "normal" and "incident days"



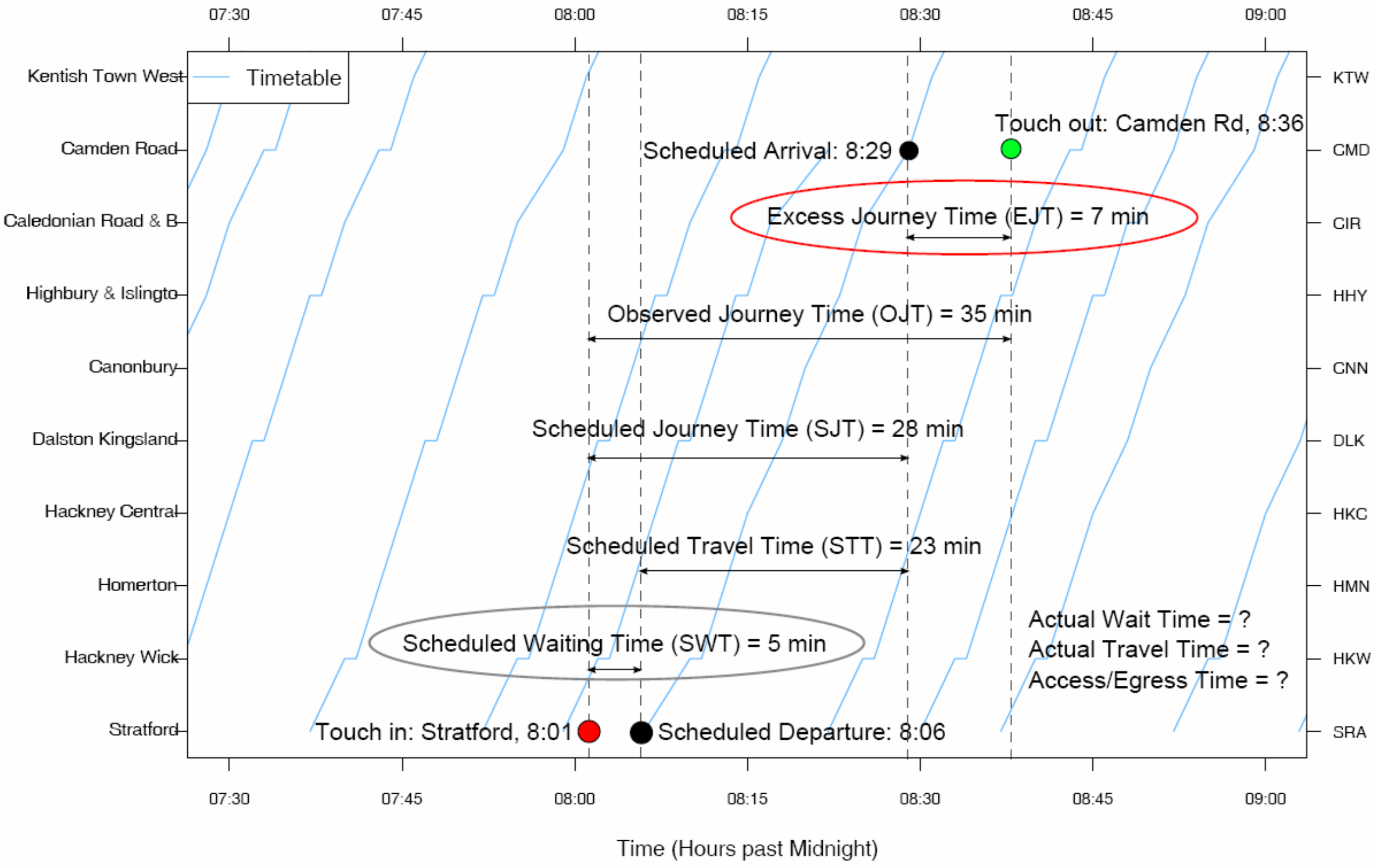
Victoria Line, AM Peak, 2007

Source: David Uniman, MST thesis, MIT 2009. *"Service Reliability Measurement Framework using Smart Card Data: Application to the London Underground."*

Reliability Metrics - Rail

B. Low-Frequency Service

- compare actual journey times with scheduled times
- compare actual journey times



Source: Michael Frumin, MST thesis, 2010 "Automatic Data for Applied Railway Management: Passenger Demand, Service Quality Measurement, and Tactical Planning on the London Overground Network."

Reliability Metrics - Bus

In contracted service delivery context, need to distinguish between:

A. Contractor performance: measure against contracted service expectations

B. Performance as seen by passenger

If service is unreliable, <u>the passenger</u> doesn't care whether the problem was caused by traffic or poor operator behavior, but <u>the authority</u> must be sure which caused the problem.

Reliability Metrics - Bus

Challenge to measure passenger journey time because:

- **(typically) no tap-off, just tap-on**
- **tap-on occurs <u>after</u> wait at stop, but wait is an important part of journey time**

Strategy to use:

- **trip-chaining to infer destination for all possible boardings**
- **AVL to estimate:**
  - **average passenger wait time (based on assumed passenger arrival process)**
  - **actual in-vehicle time**

Summary Information on London Application

- Oyster fare transactions/day:
  - Rail (Underground, Overground, National Rail): 6 million (entry & exit)
  - Bus: 6 million (entry only)
- For bus:
  - Origin inference rate: 95%
  - Destination inference rate: 80-82%
- Computation time not an issue (even for London)

Reliability Framework: Strategies

Preventive

- Maintain normal service; robust operating plans
- Reduce probability of problems occurring

Corrective

- Return to normal service once problems arise
- Minimize impact on passengers

Reliability Framework: Preventive Strategies

- Reserve fleet of drivers and vehicles
- Exclusive bus lanes
- Fare payment off-bus
- Traffic signal priority
- Route design strategies: shorter routes, less stops
- Schedule planning
- Supervision

BRT does much of this

Impact of Schedules

Critical decisions:

- **Cycle time/half cycle time: impacts cost and terminal departure reliability**
  - **Allocation of time between running and recovery time**
- **Time Points: impacts cycle time and/or recovery time, reliability along route and passenger trip time**
  - **Number and location**
  - **Schedule at each time point**

Impact of Schedules

Traditional scheduling approaches

- Set half cycle time so that 90-95% of vehicle departures are on time
- Set time point scheduled times at 65 percentile of observed running times

BUT

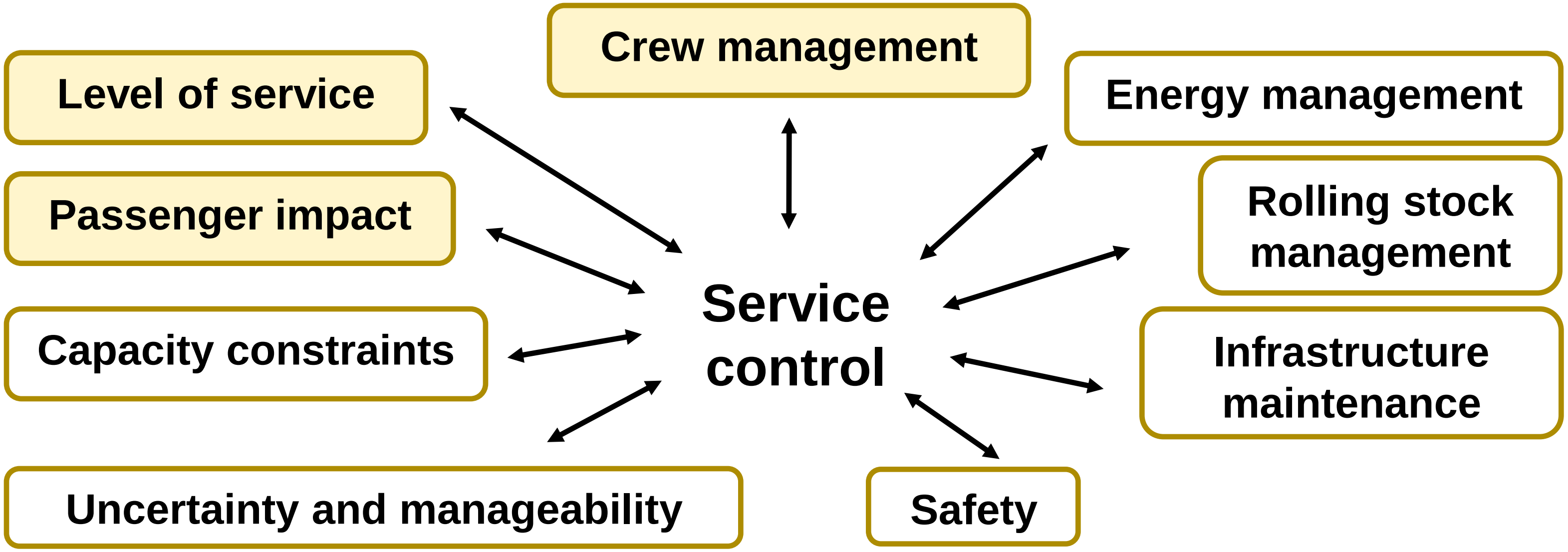
- This doesn't recognize the feedback between scheduled time and operating speed
- It is not sensitive to the ratio of passengers on board versus passengers waiting at time point and further down route

Reliability Framework: Corrective Strategies

- Supervision, operations control
- Holding: schedule- vs headway-based
- Expressing
- Short-turning
- Use of reserve vehicles
- Traffic signal priority

}major disruption strategies for high-frequency service

Rail Operations Controllers Decision Factors



Crew management

Level of service

Energy management

Passenger impact

Rolling stock management

Service control

Capacity constraints

Infrastructure maintenance

Uncertainty and manageability

Safety

- These factors can trigger service control interventions or place constraints on interventions performed for other reasons
- Conflicts between objectives are frequent
- Service control can cause unreliability!
- The question is: How can we best coordinate and integrate these objectives and constraints?

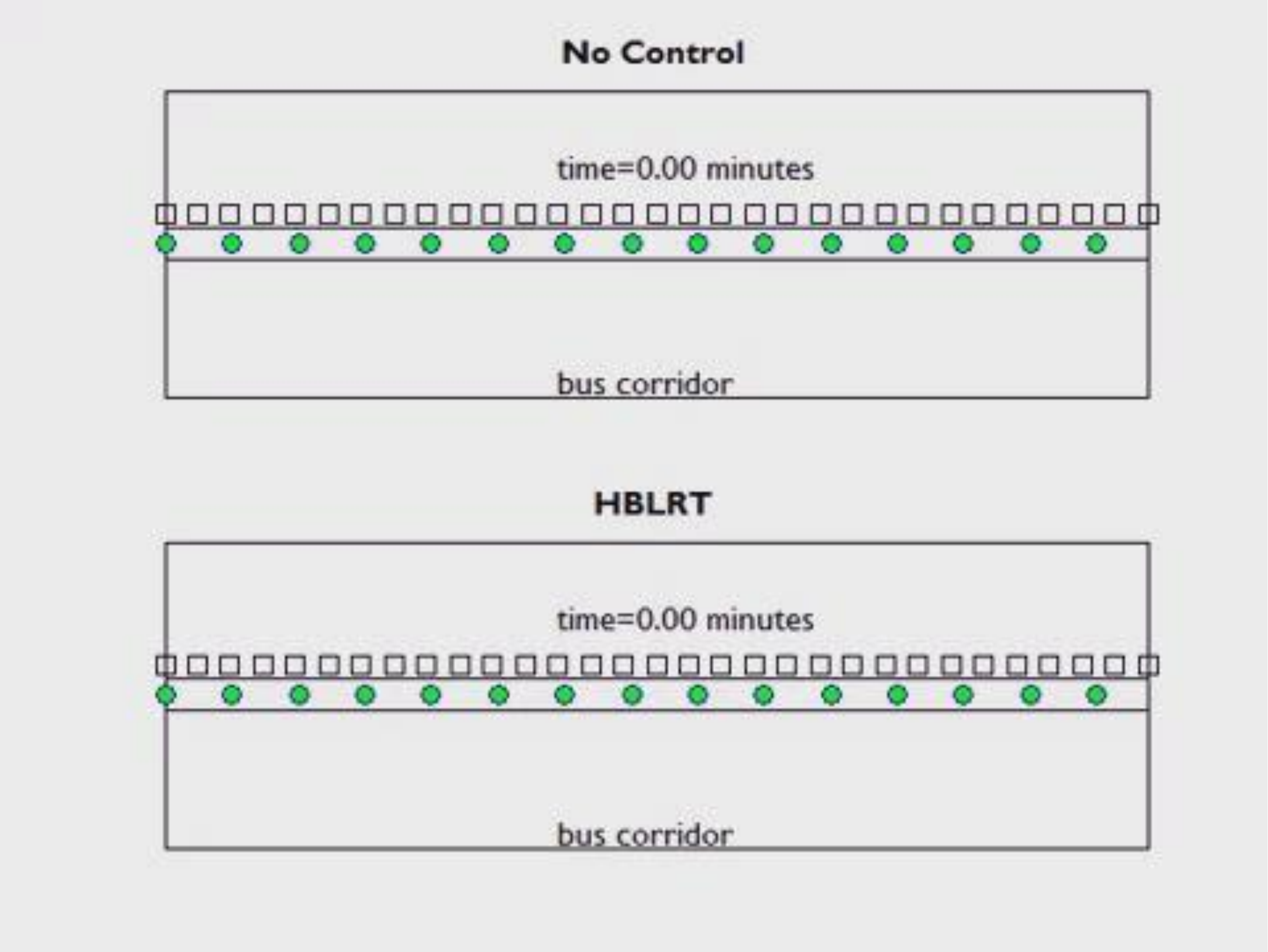
Source: "Diagnosis and Assessment of Operations Control Interventions: Framework and Applications to a High Frequency Metro Line." MST Thesis, André Carrel; MIT, 2009.

State of Practice in Operations Control

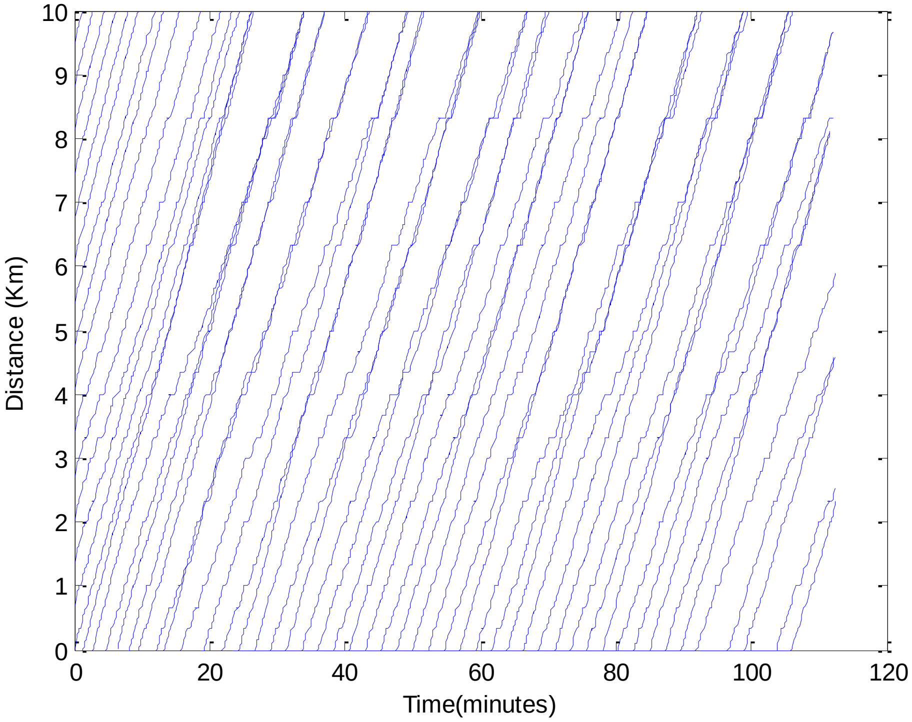
- Advances in train control systems help minimize impacts of small incidents
- Major disruptions still handled in individual manner based on judgement and experience
- Little effective decision support for controllers
- Simplistic view of objectives and constraints in model formulation
- Substantial opportunities for more effective models

Research results…

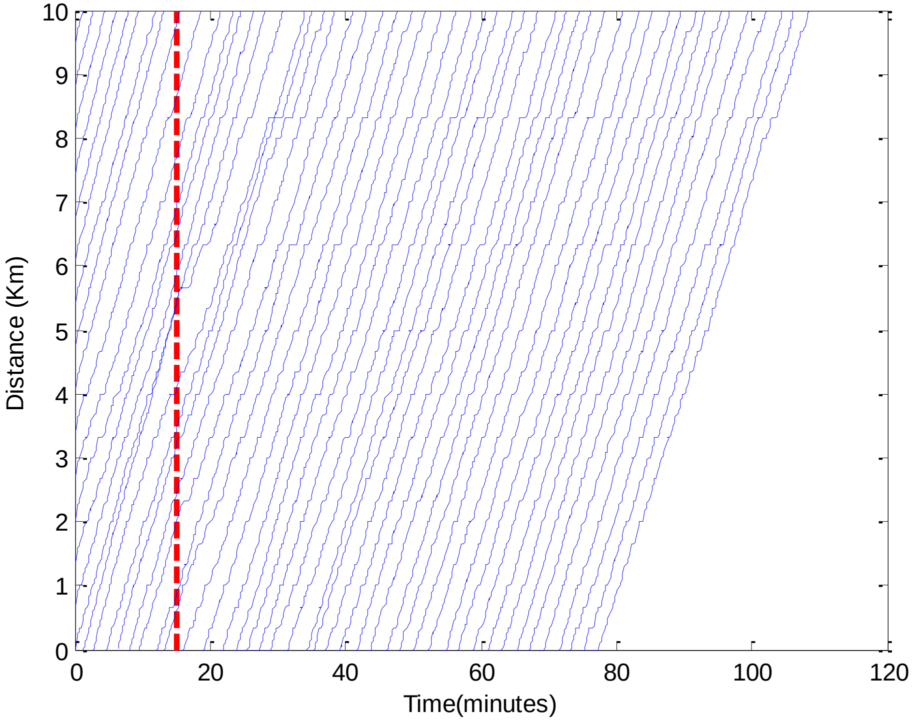
Headway control



We achieve regular headways!



No Control

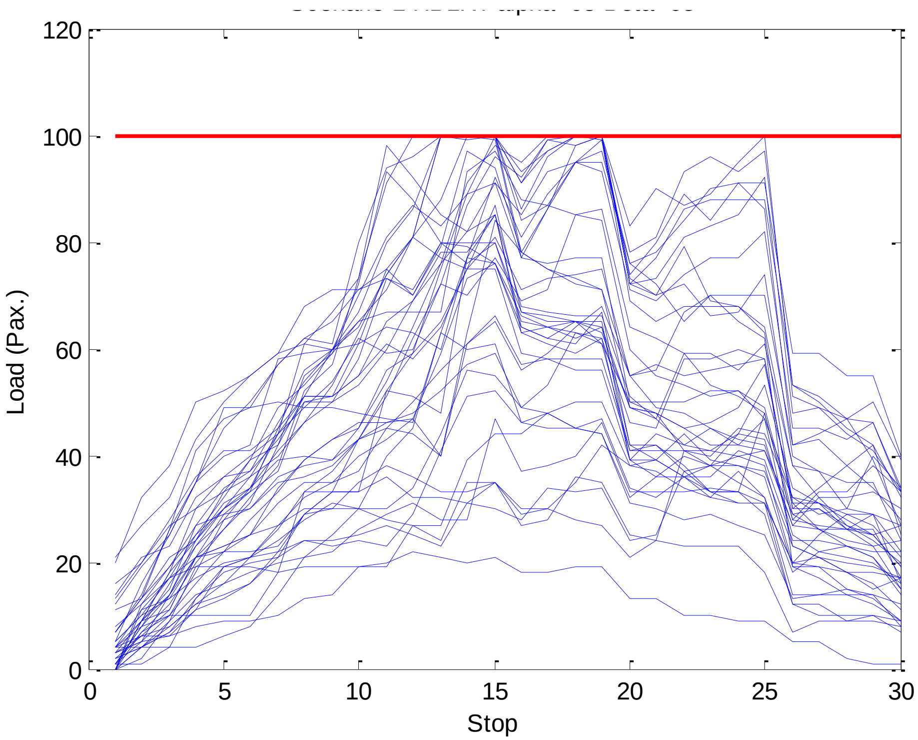


Control

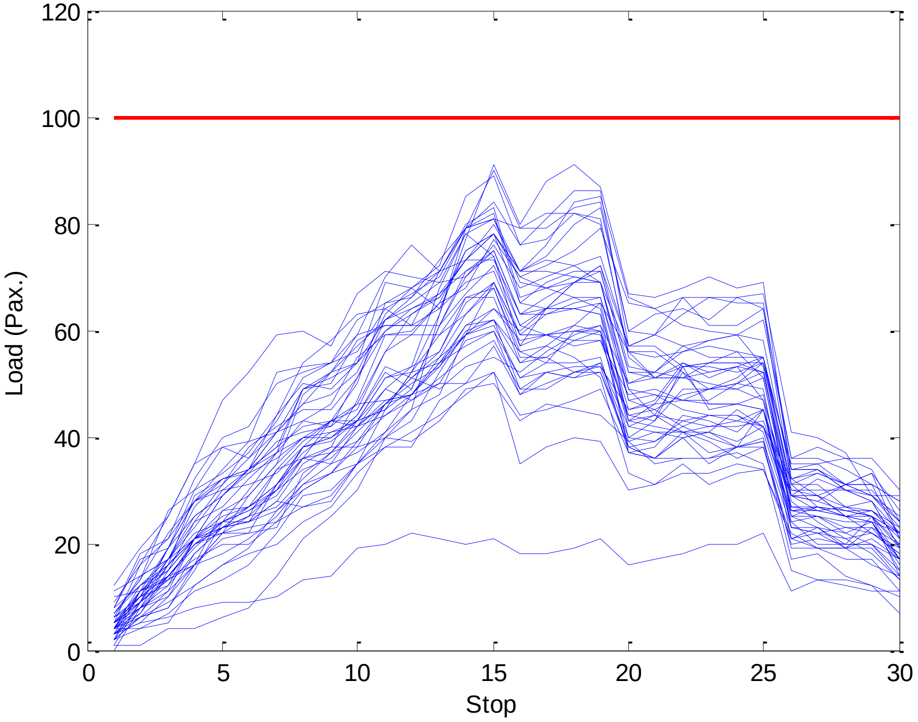
Excess Waiting Time Drops!

	No control	Simple control	Sophisticated Control
Wfirst	3654.20	667.14	73.06
Std. Dev.	1196.42	738.44	188.96
% reduction		-81.74	-98.00
Wextra	777.65	379.24	343.60
Std. Dev.	784.90	608.44	120.95
% reduction		-51.23	-55.82
Win-veh	156.52	2004.85	1020.95
Std. Dev.	68.80	669.44	110.13
% reduction		1180.87	552.27
Tot	4588.37	3051.22	1437.61
Std. Dev.	1920.05	1966.02	320.08
% reduction		-33.50	-68.67

Comfort Reliability



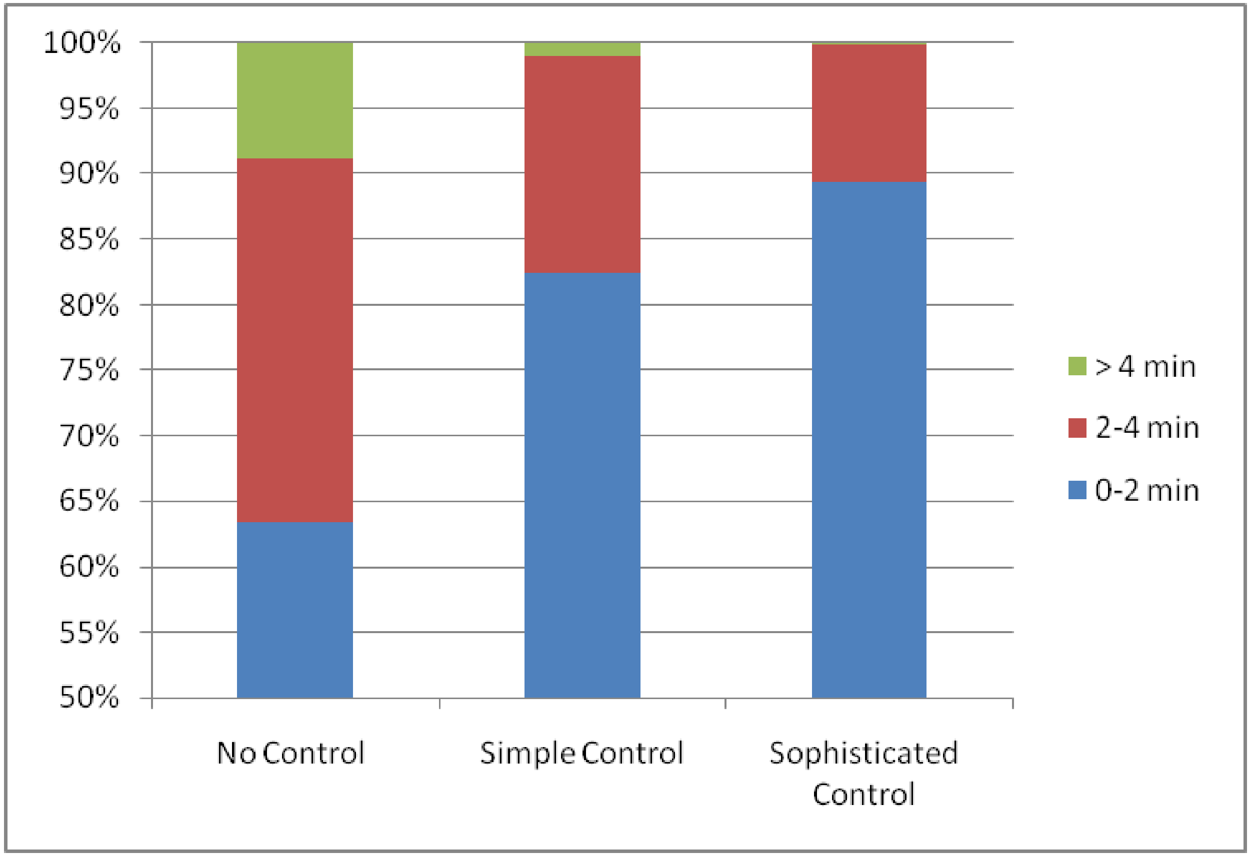
No Control



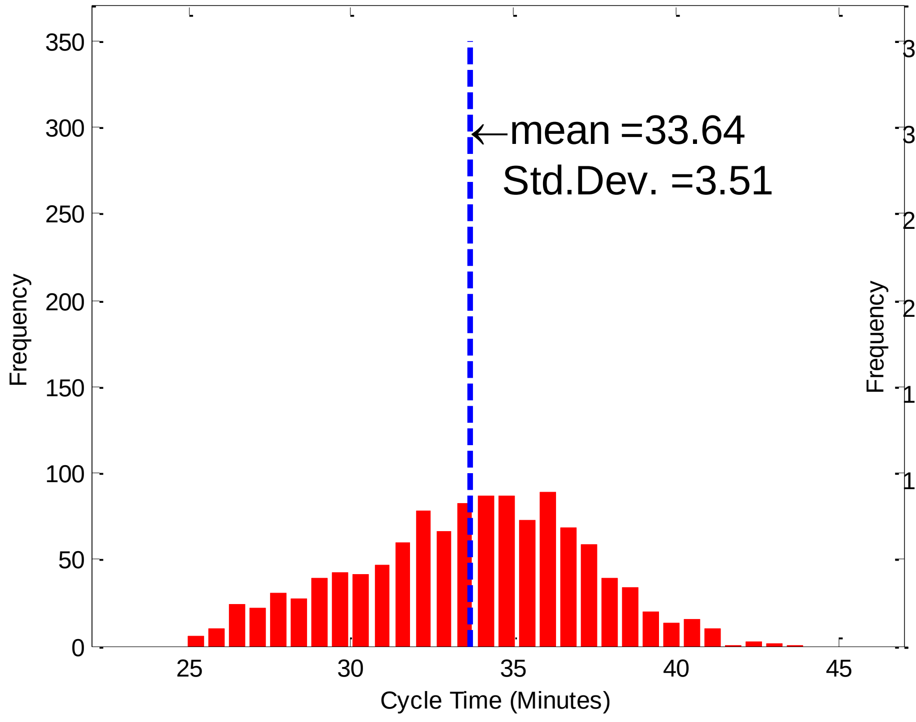
Control

Impact on Reliability for the Passenger

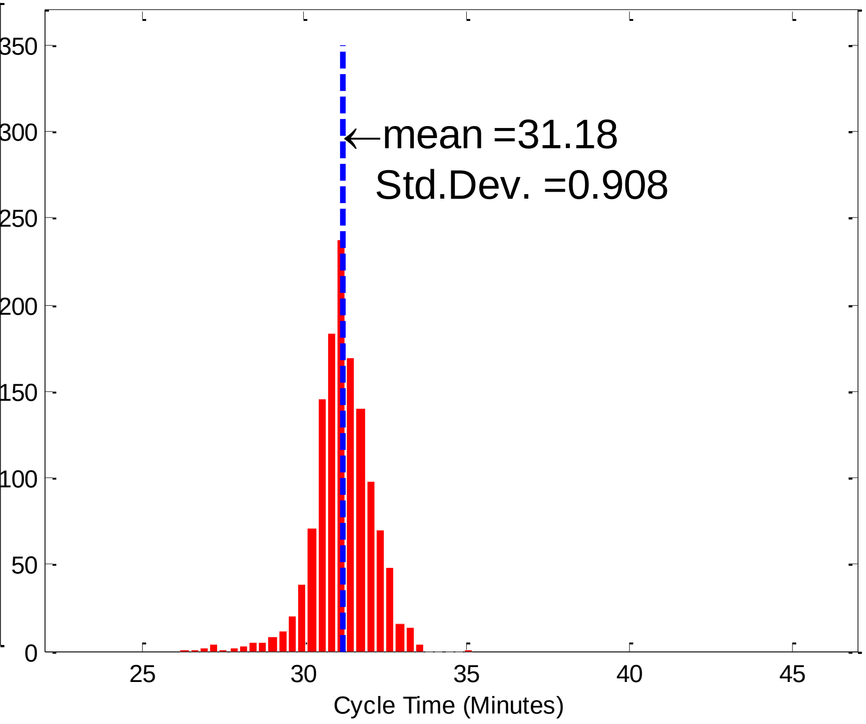
- **Waiting time distribution**



Impact on Reliability for the Operations



No Control



Control

IMPACTS

- Reduces waiting time excess in 60%
- Evenly distributes passengers across buses
- Reduces cycle times (7%) and variability (25%)
- Reduces passengers waiting too much to 2%

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